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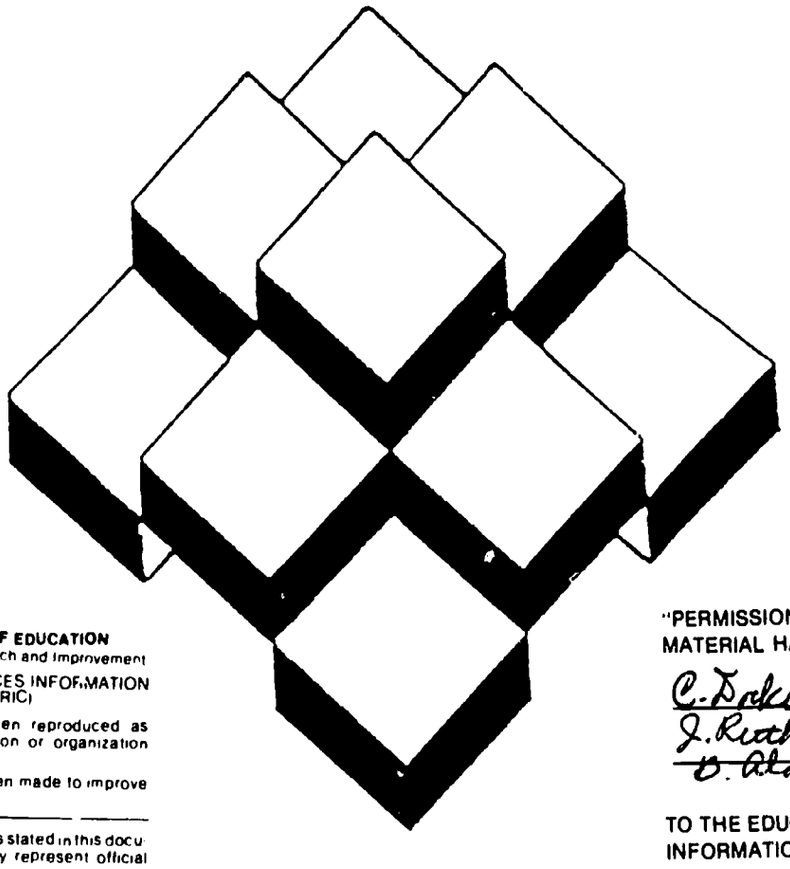
ABSTRACT

This report of proceedings present papers and commentary from an invitational conference called by the Center for Mathematics and Science Education (Texas A&M University) to consider school science education reform. Topics of discussion were Project 2061 (American Association for the Advancement of Science) and the Scope, Sequence, and Coordination Project of the National Science Teacher's Association. Each project addresses basic changes in the organization and presentation of the science curriculum and emphasizes an integrated approach to the study of science, including the components of problem solving and higher order thinking skills. The report includes two keynote addresses: "The Implications of National Science Education Reform Efforts" (James Rutherford) and "Scope, Sequence, and Coordination Project" (Bill G. Aldridge). Both addresses provide a relevant context for discussion of the ideas of the two reform projects and their extensions to teacher education. Subsequent discussions by participants are synthesized and included in the document, along with a list of participants. (LL)

SCIENCE EDUCATION REFORM: IMPLICATIONS FOR TEACHER EDUCATION

CONFERENCE PROCEEDINGS 1991



CENTER FOR MATHEMATICS AND SCIENCE EDUCATION
TEXAS A&M UNIVERSITY

SCIENCE EDUCATION REFORM: IMPLICATIONS FOR TEACHER EDUCATION

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MAY 17-19, 1991

Editor:
C. J. Dockweiler

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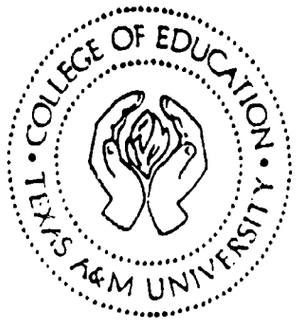

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ACKNOWLEDGEMENTS

The Center for Mathematics and Science Education

Educational Curriculum and Instruction
Department Members

C.J. Dockweiler, Director

Robert James
Delmar Janke
Gerald Kulm
James Rollins
Janie Schielack
Carol Stuessy

Graduate Assistants

John Fossa
Bill Jasper
David Leeth
Mona Majdalani
Bonita McMullen
Kathleen Mittag
Gilbert Naizer
Carol Simmons

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INTRODUCTION

Clarence J. Dockweiler
Texas A&M University

The teaching of science in the elementary and secondary schools of this country has been analyzed and studied to a considerable extent. At least two of the most significant efforts, Project 2061 (American Association for the Advancement of Science) and the Scope, Sequence, and Coordination Project (SS&C) of the National Science Teacher's Association, will, apparently, effect change in many schools.

The goals of these two science education reform projects are ambitious indeed. Project 2061 is a long range project which is attempting to build an approach from the ground up which meets the needs of the learner, the sciences, and society. The SS&C Project includes a program and activities which are designed to have immediate impact in secondary school science. Each project addresses basic changes in the organization and presentation of the science curriculum. The emphasis is on a meaningful integrated approach to the study of science while including problem solving and higher order thinking skills as an important component.

In addition to these two major national efforts, the State of Texas, through the Texas education Agency (TEA), is taking a serious look at science education reform. The initial emphasis of TEA is the science programs of grades 7 through grade 10.

The Center for Mathematics and Science Education of Texas A&M University sponsored an invitational conference to consider the implications of these developments in science education for teacher preparation programs. The Conference entitled "Science Education Reform: Implications for Teacher Education" was held May 17 and 18, 1991, in College Station, Texas. Invited participants included science supervisors from public schools, science educators from higher education, representatives of the publishing industry, and classroom teachers (list of participants included). Those of us responsible of the scheduling and program deemed the Conference a resounding success. The keynote presentations were right on target and the ensuing

discussions were productive as the pages of these proceedings will attest.

The two principal advocates of science education reform were keynote speakers for the Conference. Dr. James Rutherford (Project 2061) and Dr. William Aidridge (SS&C) provided a meaningful, relevant context in which to discuss the ideas of the two reform projects and their extensions to teacher education. To extend the two project presentations, each project was represented by site personnel to discuss the development of activities and classroom practices which have already taken place.

Following the presentations and project discussions, the participants were able to contribute in a meaningful way to subsequent conversations which were to focus on the role teacher education should be assuming in the preparation of science education for this new day. The small group discussion summary reflects the extent of deliberation that the keynote addresses initiated.

The proceedings are designed to stimulate further discussion. The participants will be invited to react to the document and they will consider the formulation of recommendations based on the Conference Proceedings.

Recognition is gratefully noted of the involvement and commitment of colleagues and graduate students in Conference planning and preparation. The corporate sponsors were particularly generous in their financial support and their recognition that this was a worthwhile project. A successful conference depends on the work and interest of many people - we had an abundance of both.

FIRST KEYNOTE ADDRESS

DR. JAMES RUTHERFORD

PROJECT 2061

THE IMPLICATIONS OF NATIONAL SCIENCE EDUCATION REFORM EFFORTS

Teacher education is an appropriate thing to look at, and I think rather neglected in terms of how we are going to bring about reforms in elementary and secondary education, so I'm delighted to have you think about this and to have the privilege of presenting my ideas to you about it. I think one has to recognize when we say teacher education we're talking about a very complex system of events and places and undertakings. It's not just something having to do with colleges of education and it's not something to do simply with the academic departments either - they're both part of the problem that we have right now. Teacher education has to do with the kind of content knowledge teachers must have, and their craft skills. Every advanced profession has a set of craft skills that have to be mastered in order to do the work. It also has to do with licensing and credentialing - a sad story in America in which states all over the country pretend to enforce standards for entry into the profession when, in effect, there are essentially no standards when it comes right down to it. It deals with recruitment and placement of teachers - what is the process for how people become teachers?

Local and National Perspectives

Teacher education is probably the last of the parochial activities. It's strange, that we think that universities are in the business of producing teachers for schools that happen to be nearby. Or in their state. What's the logic that Texas A&M should be producing for Texas as opposed to Connecticut, or North Carolina, or New York? Is there something different about science and mathematics in Texas, something different about children, something so different about the culture that only a person educated to be a teacher here could possibly operate? Localism is part of our sloganeering in this country, but I think that's part of the whole proposition of how you get a teaching faculty whose standards are whatever dimension you want. There's the whole question of market competition. You know there are three million of us who teach school in America - the largest single profession there is. You have to get those people by having them choose teaching instead of something else. So, there is constant competition with the sciences, with law, with medicine, with business, and so the circumstances that create the market for employment of

teachers determines to a very large extent not the quantity, but the quality of the people that you can get. In fact, quantity and quality are inter-mixed and part of the whole problem and confusion in teacher education. We just haven't looked at the entire system by which the nation develops its teachers. You understand that I am speaking from the national perspective. I do not take the view that America is made up of 50 entities. We are a nation, where people move everywhere. They don't stay in Texas, they don't stay in California. We are a dynamic moving society. So when one looks at teacher education from the national point of view, it seems to me that we haven't investigated the kinds of institutional rearrangements that may be necessary, the employment practices, or the whole question of continuing education of such a large profession which, as you know, is underfunded, is feeble, and practically doesn't work.

Education Reform

All of these questions are about the current failure of the teacher education enterprise in America, an enterprise incidentally in which there are 1300 institutions of higher education engaged, some of which probably do not match the standards of a good high school. It's not at all clear that we need any more than perhaps 300 institutions to do the job if you take a different view of how teachers are selected and prepared. The reason for launching into a reexamination of the teacher education enterprise is that reform is in the air. We are talking about it, and in Texas and a few other places, we are doing some things about it. If you are going to have reform, if you take that to mean that you are going to change the nature of schooling - the curriculum, the content, the way in which business is done in some fundamental and dramatic ways - then it seems to follow, that we have to start thinking about how to produce the teachers who are able to carry the reform forward. How do you produce them in the right quantities, along the right path, so that they fold into the system at appropriate times and ways, and so that over a period of a quarter of a century or so you can gradually change the character or the nature of the people in the profession. So, reform calls for us to think about teacher education, what is it we would like people to know and be able to do, and how can we make it possible for reform to happen?

I propose to talk about reform in teacher education from two perspectives; one being that of

the nation as explained by President Bush and Secretary of Education Alexander, and then I would like to talk about just one reform project, namely Project 2061. As you already know, the Bush administration has an education initiative in which science plays a major role. I think it would be useful to see the implications that each of these approaches to reform have for teacher education. What each seems to be telling us, what each would like to do, what it means for teacher education.

The Historical Context

The first thing I think you have to look at is the context of reform. John Fackler said that it makes a difference in what you think the purposes of reform are, why you need it, and what's driving you to want to change the system. I'd like to remind you that the United States on the national level has been engaged in science education reform since World War II. The current reform movement didn't really begin this decade, it began during the war. James Bryan Conant, the well known scientist, distinguished person in world affairs, and President of Harvard University, pointed out that a new understanding of science in relation to culture and society was needed. And it was shortly after that that he went to Harvard and produced the famous Red Book - Science Education and a Free Society - which still may be one of the best things you can read on the topic of science education reform even though it was for one rather peculiar institution. But, the motivation, the articulation of why we had to reform science education has changed. After World War II, the reason was industrialization. We were an agricultural nation becoming an industrial nation and therefore the old education would not work. Part of the reasons for the GI Bill wasn't because we didn't know what to do with all the GI's coming back, but rather that they weren't properly educated for the new industrial world. Then, toward the end of the 1950s, we got into the Cold War, with Sputnik and the race to the moon - it was like a super bowl that no one knew who would win. And that race was the driving force that provided the political energy for the so-called reforms of the 1960s that many of us were engaged in and which shaped the way we went about our work.

These previous reforms by and large did not question the organization or the structure of schooling. The purpose of Project Physics or any of the others, was to do a better job within the

given structure. The political troubles in the 1970s generated a few reform ideas, but they didn't get far. But two things happened in the 1980s, at the very time the Reagan administration was trying to get rid of the Department of Education and were canceling out education programs at the National Science Foundation. First, we discovered that on the world economic front, we were in trouble. Germany and Japan seemed to be passing us by, taking over the classical American position in the world. The second involved low test scores, which actually started to go down long before. The current federal reform effort is driven primarily by economic competitiveness. I want to come back to that because I think that is narrow, limited thinking, not fundamental enough to sustain reform for the 25 to 30 years it would take to create a new system.

The Federal Plan for Reform

So let's examine the administration's plan by pointing out that the President and the Governors have agreed that we have six national goals to reach by the year 2000. The list includes 1) ensure that every child starts school ready to learn; 2) raise the high school graduation rate to 90%; 3) ensure that each American student leaving the 4th, 8th, and 12th grades can demonstrate competence in core subjects; 4) make our students first in the world in math and science achievement; 5) ensure that every American adult is literate and has the skills necessary to compete in a global economy; and 6) liberate every American school from drugs and violence. Science and mathematics come out very well, don't they? They are mentioned in two of the items. Items three, four, and five, in a way, are the substantive part, and one, two, and six are mechanisms, for presumably if you keep kids in school they'll learn more - that hasn't ever been particularly demonstrated but it's a belief.

Notice in this list or the versions you have read that are extensions of these, there is no mention of teachers. Teacher education may be inferred from this; that if you want to be first in the world in math and science you ought to have the teachers that can get that to happen, but you have to infer it - there's nothing in the national goals that makes that kind of claim. Now you may wonder, since math and science educators feel good about getting double mention, especially number four which sounds terrific, what do you imagine the public thinks? Gallop recently

conducted their annual poll on education and they asked folks which of those six goals should be given the highest priority - how would they rank them and which of them are feasible to achieve. The public says that being first in the world in science and mathematics ranks dead last and that the other things need to be attacked first. And then, if you talk about feasibility, what's the likelihood that we can achieve any of these? I just mention that to point out that when we talk among ourselves you can get the impression that the world out there, the country, is just so eager for us to get good in science and math, but it doesn't show up in the data.

Now if those are the goals, our leaders have a strategy called America 2000. The strategy is described in a document - America 2000: An Educational Strategy. On page one, the document states "America 2000 is a national strategy, not a federal program, that honors and affirms states and localities as the senior partners in paying for education." A message in the document from Lamar Alexander, Secretary of Education, further explains that "The America 2000 Education Strategy is a bold, complex, and long-ranged plan." The glossary of the book includes 20 key terms such as "America 2000 Communities," and what you have to do to become an American 2000 Community, "Better and More Accountable Schools," the definition of which is a fifteen-part improvement package for today's schools, which has to do with school choice and report cards. There's the new "American Schools Development Corporation," which is a private entity to fund R&D to create the new schools. It's interesting that the one federal enterprise that everyone agrees should be federally funded - educational R&D - will now be turned over to business and industry. And one last term: "Unleash America's Genius." This has four parts. Part one says "first we have to fix up today's schools" and goes on to describe how to do that and then we want to invent what they call the New Generation of American Schools. Then there's continuing education that we have to provide for all adults, and finally, communities and families have to be brought back into the picture in education.

Now I don't want to quibble, but I would call those goals rather than strategies. I don't think that matters as much as the chance it gives us to examine the document in relation to teacher education. Teacher education doesn't appear in the list of strategies, or even in the sentences that

describe those strategies. Let me note that in the first strategy - Better and More Accountable Schools - they discuss achievement tests, Presidential citations and scholarships, report cards to the nation, and choice. Finally there is an entry called, the School as Site of Reform, which is buying into the notion that it's the local school site where reform will really take place. That idea has a consequence for teacher education. If you believe that local reform is necessary, then I suggest that teachers have to learn how to create new curricula and new schools. Teachers have to develop the skills to do this unless you believe that school site reform is a simple matter. There are other ideas about schools, such as the Governor's Academies for Teachers, Differential Teacher Pay, Alternative Teacher and Principal Certification, and Honor Teachers. So, in the goals for Improving Today's Schools, there is some mention of teachers or teaching, but no call whatsoever for changing the system fundamentally.

If you look at the chapter on Creating a New Generation of American Schools, there is nothing that I could find that deals with education of teachers, but there are two things that I think are implications that we have to pay attention to. One is called Breaking the Mold. This is a quote, "The R&D teams," those teams that the private sector are going to fund, "can be expected to set aside all traditional assumptions of schooling and all the constraints that conventional schools work under... time, space, staffing, and other resources... , radically alter the customary modes of teaching and learning, and redesign the human relationships..." and so forth. Now, not only does that sound good to the ears of Project 2061, but it seems to me that there are implications for teacher education. How is that going to happen unless we create teachers who are ready psychologically and intellectually to operate in a vastly different enterprise from the one that exists now? You can't just create something new without having the people who can operate it. And so if that comes to happen, then it seems we would have to simultaneously figure out how to do something about it.

The last item in this category is Bringing America On Line, by which they mean that they are going to convene a group of experts. Calling or leading a committee really seems like the necessary first step for anything, but they are going to get these experts together and "determine

how one or more electronic networks might be designed to provide the New American Schools with ready access to the best of information, research, instructional materials, and expertise." It does not mention that the continuing education of teachers in the future will almost certainly have to be delivered by going and getting teachers on line into the new, technological information-delivering systems, and learning systems of the future. There is no mention of it, but we can infer it and behave as though that's what they have in mind.

To be fair, let me say that there is in Washington a level of energy now, a determination that hasn't been there since the 1980s when the Reagan administration came in, that will at least articulate the need for reform in education. They are going to keep it on the national agenda, you can count on that, for at least two, probably six years. And that's an advantage. What we have to do is to make sure we take advantage without buying into some propositions that we may not want to support. But even if the administration sticks to its guns, there is not enough money to have much influence anyway. They are requesting another $690 million for their strategy in the '92 budget. Now $690 million is less than one half of a percent of what we spend on education. That's less than inflation; it hasn't anything to do with reform; it's not money. A direct quote from the plan says: "But America 2000 is not expected to raise state or local spending." So they're not going to put much money in and they are saying this strategy won't require local and state government to put much in either.

The Project 2061 Plan for Reform

Well let's look at 2061. The details of Project 2061 will be presented by Peggy Carnahan and Deb Larson, two of our team leaders, one from Texas and one from Wisconsin. We believe you have to spend money in large quantities, but let me express my own bias on this. The schools spend too much for what they currently deliver. The rhetoric that says we don't have a cost-effective system is correct, but we will never get one unless we make capital investment in changing it. And that investment is measured in some large number of billions of dollars. If we don't solve that problem, all the good will in the world won't quite make it. Let's get back to the question of why you want reform. Remember that I pointed out that economic competitiveness,

along with low test scores, is the driving force of the current federal initiative. Actually, the fundamental and lasting reason that we have to change science education is that the world has changed. The last hundred years have seen an incredible change in the way a large fraction of the world's population lives. We're in the third century of the great revolution of the human enterprise, fueled by science and technology and mathematical thinking. The schools here, or anywhere else in my view, have not yet been able to recast themselves to deal with this changing cultural phenomenon that we're undergoing. We're in the middle of a vast cultural revolution in which science is coming to be the central purpose - the role religion had in the Middle Ages. The kind of central position that, if you don't understand it, you're simply out - you are not even a spectator, let alone a participant.

The reasons for people wanting and needing to know something about science and mathematics surely has to do with utility; it does have to do with getting jobs, it does have to do with a country being able to have a good economy. Surely it has to do with social responsibility and democratic societies where we all participate in making decisions that knowledge and understandings can only help. Incidentally, scientists never provide answers, they don't agree on almost any of the social issues of the day, but that's important. But more than that, at any one time knowledge has intrinsic value in its own right. There are some things we have produced collectively over the centuries that are so central, so important, so significant, such a measure of what the human race achieved, that an educated person should know something about them. It's true in literature, it's true in the arts, it's true in science and mathematics, and in the great inventions of technology. And even deeper than that is the notion that what science is doing now, has been doing for 300 years, is on the forefront of helping us all come to better understandings of ourselves, and ourselves in relation to other persons, society, and to the natural world where we are in space and time and history. You only have one lifetime and it isn't just to work, to help out the country's economy; it's to gain some understanding of yourself as you move along.

And finally, in this cultural change that's taking place, if you want to participate, if you even want to be a good spectator, if you want to be in on this incredible adventure in which every

day the newspaper brings new and exciting information about the world, then you must have some understanding of what is happening. If you haven't the knowledge, you haven't the concepts, you haven't the language, then you can't be part of it, and that's a loss, and that deprives you. This is true whether you are a child or an adult. These are the things that persist and become even more important no matter what our economy does. If you believe that this vision of the world and human endeavors is the driving force for the need for reform, it does have consequence for teacher education. We need people in teaching who have broad perspectives and understand the purposes of what they are about. They should understand history, not only history of science, but the history of the world and the human race. They should understand liberal arts and sciences in their classical meanings.

Project 2061 has identified four strategies for reform. These four strategies indicate possible implications for teacher education. Let me first discuss one of the strategies, Establishing Visionary Learning Goals. That's what Science for all Americans attempted to do. It attempted to communicate what's fundamental; what would you like everybody to know, after they've forgotten everything else, after you've taught them all you can teach them, and you've taught it to them three times and then it drifts off - what is the residue? Not only what, but in what sense, in what context, what's the character, what are the interrelationships of the knowledge. That's why it is an essay instead of a list - those interminable lists of objectives - because to understand the sense in which you need to understand things, the levels of sophistication, the kind of vocabulary, you need to lay all of that out, otherwise the things are slogans and lists.

For teacher education, Science for All Americans says everyone in education, at any level, of any subject, ought to have all of their understandings, but should go considerably beyond that. And if you take the notion of comprehensiveness seriously, there needs to be a teacher education plan that involves all the kids and all the teachers of all subjects and all grade levels, going beyond teacher education only in science. We're not simply talking about the education of people who are going to wear a label saying "I am a science teacher." History teachers must learn science and understand how it fits into history, and social studies teachers, vocational teachers, and technology

education teachers must do the same thing. It says to teacher education: you have to come out into the world if you are going to be in this enterprise, really understanding the scientific enterprise. That doesn't mean going into a lab and doing an experiment. You can do experiments by the hundreds and have not the foggiest notion what science is all about because that's not the way science really works, it's not the way knowledge is advanced in science. Teachers need an understanding of science, the sciences in relation to each other, to mathematics, to technology, how knowledge is advanced, what the limits and constraints are, and be able to see the world through the eyes of science. The purpose is not to understand physics, or chemistry, or biology - why do people have to understand every field you can mention? The purpose of education is to help people understand nature and social structures. And the real question is what do the sciences bring to bear that will help us get better understanding of ourselves and our world, the natural world and the social world, and the way things work? It's understanding the world that counts, not being able to prove that you know the structure of physics. In addition, teachers must understand the perspectives that cut across the disciplines. If you don't know how the sciences fit in to the fabric of humanity and understandings and behavior, then you're simply following a thread and you don't see the tapestry, and that restricts the value of your education. And finally there are those things called habits of mind. Not quite scientific thinking. I don't know what scientific thinking is, I don't know what critical thinking is, and higher order thinking skills. There are ways of addressing thinking in terms of evidence, in ways of drawing conclusions from evidence, in ways of displaying ideas, in what you ask questions about - how to use logic. So there are ways of thinking that have to do with the way the scientific enterprise works. And teachers, all teachers, need to come out of college with all of these things as a part of what they know. As for comprehensiveness, not only are teachers going to be able to work with each other and across fields more than they do and make other connections, but they're also going to need to be able to relate them to the other dimensions of the system.

The Reform of Teacher Education

What we are doing in Project 2061 now, and have been doing for two years, and still have

a couple more years to go, is to look at all the other dimensions of the system in relation to what new curricula would look like across K-12. For example, our blueprint on teacher education will specifically raise and address all the issues that we are able to identify in creating curriculum models. Just let me mention one or two of these. Imagine an organization in which high school teachers do not teach 25 hours a week. Teachers may teach ten or twelve hours, when they do a lot of coaching, when they run clinics, where they supervise students who do a large fraction of all the teaching, where they work with other adults who come in and work in the schools to bring teaching and understanding into the school in a variety of ways. Once you've changed the organization, you need a new kind of teacher who has different kinds of skills - intellectual skills, managerial skills - a different sense of how one goes about doing the work.

Take the case of materials and technology. Suppose the question before long isn't whether California and Texas agree on defining a textbook, but that with all the curriculum projects going, we move toward diversity and toward new ways to deliver science content. If fundamental, technological changes are made in the way kids address knowledge and work with it, the role of the teacher changes. If you have systems that deliver, electronically, pieces of material that together make up a kind of structure for a kid, or a few kids, or an aggregate of kids, then you need teachers who think differently about how they work. They don't work their way through a textbook any longer; they take bits and pieces and form them together in relation to a task they're trying to work out, in relation to what they know about the development of children, using the basis of curriculum developed by experts.

Consider the question of assessment. If you sort out the purposes of trying to find out something about what is being learned, by far the most important factor has to do with the relationship between a teacher and a student; that privileged relationship that really is no one else's business, not even the parents. It's like the physician patient, the lawyer client relationship; that is, it is a close, intimate thing having to do with working for a child, not to make judgments about their quality or what they are going to do next, but to help them master some ideas or skills that have been decided upon. That means that the assessment, this difficult job of discerning how a

child is moving and what they are learning at any time in relationship to where you think they should be, will take enormously sophisticated skills as well as new tools for teachers to use. That's one of the most important things they're going to have to learn in the future. Assessment for the purposes of informing third parties - parents do have the right to know something about individual students, so do colleges, and so do future employers, and the military. Teachers have always been the best source of judgement about a child and how hard they work, what their personality is like, what they seem to learn well, and what they don't learn so well. You don't need fancy tests for that, you need teachers who have been developed to be sensitive and clever at making judgments. By and large that would be a communal judgement done by a set of teachers that watch a child over time in lots of different contexts. It's only when you get into the third kind of assessment - how is the system working - that you can have policies. That's a tough, political problem. In my judgement, the students should be absolutely anonymous. You only need a small handful, a thousand or so, no matter what you're talking about, Texas or the country, to make some informed judgments about where they are about the system. But teachers don't have to do that. They ought to resist that approach when it's done poorly, and they ought to know enough about testing and sampling to distinguish between the kinds of testing that just overburden the system, the nonsense of testing every child in every other year or something.

Finally, let's just mention research and technology. If we expect one day to have a profession that draws more effectively on a research base, a knowledge base, then teachers are going to have to be trained to do that. Preaching to teachers about what the research says is a mistake notion, on how research knowledge gets into a field. It doesn't happen that way in research-based activities such as engineering and medicine. We have to look very carefully at how we can get a cadre of teachers who can have a sense of relationship to R&D activities on an ongoing basis. Among the tools Project 2061 is developing are databases - teachers are going to have to learn to operate databases, electronic networks, and so forth. They have to become sophisticated in technology and that doesn't mean just knowing a little bit about how to work a computer, it means much more. So teachers will need new content, new craft skills, new technological sophistication

along with better understanding of their purposes. They need design skills because they are going to be involved in the process of creating curricula. They need a research orientation. How do we accomplish all of this? I don't know, but things will have to change if there is to be any chance of doing it.

The Role of Universities

The universities are culpable. The math and science departments are contributing little or nothing to the solution of this problem; they are part of the problem. They teach science in a way that is a poor model of how science teaching ought to be done. They teach the wrong content. They won't take elementary school teachers seriously. They won't recast the knowledge in terms of the philosophical and historical and pedagogical nature in relation to kids and their development. Until they do that, we're not going to get the kinds of teachers we want. And the craft side is no better. There are very few schools of education in America that are able to take seriously the notion of turning out a person with the craft skills that would be comparable to what a young architect would have, or an electrical engineer. Maybe they can't even do it. I think the model of the law school isn't the right one; maybe it's the medical school. And maybe we can't do it in four years or five years. For something as simple as law, you need to earn a bachelors and then three years. So maybe we need a bachelors degree and then three years or four years. We need to talk about a system that looks at teacher education entirely differently, with new institutional arrangements. If there are questions about how this can possibly be achieved, part of the answer is that we have to go for quality, not for quantity. Teacher education has a very nice situation currently in that we do not have to turn out lots of teachers. We can probably develop a system that can get by with vastly smaller number of teachers, perhaps as much as a third fewer. The uses of technology will change the stakes of the game. If we imagine making this change over the next quarter of a century, the turnovers of teachers are such that the teaching staff of three million people can be replaced with a new, differently-trained staff over that period of time. These teachers would have different perspective, different knowledge, different skills, different senses of what their purposes are. And during that same time, if we reconstruct the process of teaching teachers so there are fewer of them and the

quality is higher, teaching will turn out to be one of the best jobs in the world. School teaching is on the verge now of being an extraordinary job. The newspapers are full of stories that MBAs can't get jobs, and one day a similar situation will happen with lawyers. It's very close; change the circumstances, change the numbers, change the expectations so that standards are higher, and the higher we make the standards, the more attractive it is, and the more people will want to get in. We can do it, but we can't do it tomorrow.

I applaud what you are trying to do here, you have to look at it from many angles, lay out strategy, say what will be our contribution over the next century. Work for the time, say when Texas A&M and three or four other places in Texas become premier. The big name universities are of almost no consequence when it comes to teacher education. Harvard, Berkeley, and Stanford certify a few teachers but not many. If those universities disappeared, you wouldn't know it as far as teacher education is concerned. So it's not simply that there are good universities and they are doing a terrific job, but it's a matter of recasting the enterprise. And I think there is a chance for the places that really want to be pioneering to strike out now, stick to their guns, and set the path toward a new way of thinking, attracting, and placing teachers. Placing teachers so that we can, in a quarter of a century, see that we not only have some new curricula and a new organization, but we also have the best people you can find - superbly educated, making the system work.

Resources

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SECOND KEYNOTE ADDRESS

DR. BILL G. ALDRIDGE

NATIONAL SCIENCE TEACHERS ASSOCIATION

SCOPE, SEQUENCE, AND COORDINATION PROJECT

I don't regard the Scope, Sequence, and Coordination (SS&C) Project as a radical reform. Others do, but I don't. I regard it as a rather modest attempt to reconcile solid evidence from research with practice in schools. I think the evidence is overwhelming. I think it's largely ignored, and I think it's time to make the necessary changes to take into account what that evidence suggests, and I believe it is entirely possible to be first in the world, in science not by the year 2000, but in fact, by the year 1997 or 1998, well ahead of that schedule proposed by the President. I'm talking about natural science. That's the field in which this reform is aimed. I'm not competent to deal with economics, sociology, political science, religion and ethics, morality, and all these other areas. I'm not confident that science is very successful in those areas, and in the past when we've allowed ourselves to move into those areas or to be influenced by them, science has suffered rather badly. The interest of this project is in doing something to improve natural science and to do this at the secondary school level. We have just received funds to initiate a project at the elementary school level. But I will not be involved in that; We will use people who are experts in elementary school science. What I'd like to do today is to outline quickly for you the nature of the SS&C project, try to show specifically what we are trying to accomplish and how. Then we can see how our project relates to teacher education. I think the best way to begin is to set the stage in looking at what we now have and contrasting that with what ought to be. Fortunately, I have a nice chart to use, it comes from the cover of Chemecology, a publication of The Chemical Manufacturers Association. They've taken our idea, the layer cake, and rather cleverly presented it on their publication cover. It says at the bottom, "Education Reform is No Piece of Cake." What is being shown here is the level of participation at the high school level in science in the United States. In this country, and in this country alone among industrialized nations, about 80% of the young people, study biology. This is about 80% of those who graduate from high school, which, of course, is only 75% of the population. By the time they get to chemistry, that figure drops down to 40% and you can see some frosting and other cake in the illustration representing earth science. It has been mixed in because there isn't much of it, about 11%. And then finally at grade

12 we are showing this very small 20% participation in physics. This is the national average, and in Texas it is less than 10%. What that means is that most young people participate in life science, and some smattering of earth science, and almost nothing in any quantitative science. As a consequence, we have an enormous illiteracy, quantitative illiteracy, that relate to the lack of understanding of the physical sciences. There is illiteracy even of the quantitative components of the life sciences. Essentially all young people are taking 5 hours per week of life sciences at grade 7, where we attempt to do everything we would do in 4 or 5 high school courses in life science, and compress it into the one year. This is followed by everything we would do in earth and physical sciences and chemistry compressed into one year, and then general science of some kind, compressed into one year. Sometimes these patterns are changed in various ways, depending on the state.

Then at high school the dropout period begins; if students don't have to go, they don't. And they proceed then on through this sequence until finally we have a relatively small number in physics. A typical response to this is that only certain people can learn anything quantitative, only certain select people. And of course the rest of us can't learn it, and that message is conveyed to the children. It's conveyed in every way possible, that they can't do it, and if they do this kind of thing, it's because they are going to become a scientist or an engineer, and therefore, don't bother. This is not true in Japan. If one studies hard and learns a lot in Japan, it's because he or she studies hard, not because they have an aptitude. Here in the U. S. it's because of aptitude. It's a very clever devise to avoid having to do anything. Let me just try to outline some of the evidence and what might be done to change the existing system without radical reform. I admire what Jim's trying to do at AAAS. It's going to be tough to do all that, and it will take him all time, to accomplish those goals. In the meantime we've must do something.

Let's look at some of the evidence and how it relates to practice. Consider Dempster's paper, "The Spacing Effect: A Case Study in the Failure to Apply the Results of Psychological Research. This is a synthesis piece. The Spacing effect is everywhere. The evidence for it is overwhelming. The differences are so great; it's not a matter of using analysis of variance or

t-tests. The distributions don't even overlap. The benefits from spacing the learning are overwhelming; we're the only industrialized nation in the world that does not take advantage of this research. The other kinds of research are largely connected with how you learn anything in science. And this comes out of the work of the cognitive psychologists, from Bruner to Rosaline Driver and others who were looking at preconceptions and seeing how one must build from these preconceptions to understand science. Contrast this approach to what we do in our typical courses. Biology, grade 10, chapter 3, is Structural Organic Chemistry, preceded by one page of all there is in atomic theory - Chapter 3 that is. Chemistry does a little better; they only do the atomic theory in Chapter 3. This is absolutely bizarre. It means nothing to these kids. They don't understand any of the material. Neither do the teachers who are using it. In physics, what do we do first thing? Vectors. The most abstract thing we can think of. And we throw that out in Chapter 1. That's the what is being taught. We make no effort to relate the level of abstraction to the experience of the person. We make no effort to build the experience in any systematic way. We make no effort to provide the necessary experience from which the symbols and the words and the terms have any meaning. I don't want to abandon science because we fail to do that. I don't want to succumb to the fallacy of the excluded middle. There are some of you out there who are doing things correctly, and who recognize these kinds of problems, and are doing a good job of teaching in spite of this kind of organization. And we can't ignore that; we can't just look at the terrible things going on, and assume that we've got to just destroy everything because of what is happening that is so bad. We all know that it is bad, I'm not suggesting otherwise. Well, where did we get this situation - where did the layer cake come from? When I went to TEA to testify, I got hit by an editorial in the Houston Post from somebody whom I don't know. She talked about how I went to China and came back and brought this Communist stuff and told Texas how to do their curriculum. I've never been to China myself. But the reality is there were some affite snobs up in New England in 1893 and they gave you what you've got right now. It didn't come out of Texas, I can tell you. It came out of the Committee of Ten of the NEA in 1893 when they developed the Carnegie unit. That's how you got the thing. There's research that shows that we ought to get rid

of it. I don't know of any research that shows we should keep it. Maybe you do, but I can't find it. Now what are the kinds of cognitive research that supports some kind of radical change? I've mentioned the kind of thing Rosaline Driver is doing, and others. There's other research that shows the kind of sequencing to be carried out with the materials if you're to understand what you're doing. Linda Crow, from Houston, is here and will be presenting very specific information about materials that are being developed and used with kids in schools - real schools with real teachers. And there are other sites that I shall mention shortly. Now, what's this thing called Scope, Sequence, and Coordination, and what's it trying to do? Let me just try to summarize its features, although they're in the little brochure we handed out and they're presented in greater detail in the rationale paper you will find as well. As I said before, we are concentrating on the natural sciences. We're trying to get some balance among the basic sciences of physics, chemistry, biology, and the earth and space sciences. These happen to be those disciplines in which basic laws of science arise, some of which are quantitative, some of which are descriptive. There certainly are relationships between the sciences, and there certainly are areas that are disjoint. To believe that you are going to learn science without isolating variables, is to not understand science. Disciplines exist because it was necessary to do so, and the kind of research that has been done over history in these various areas is such that the disciplines haven't been eliminated. The disciplines are becoming even more disparate. There are even more of them now than before. We once had natural science, and that's all we had. Now we have all these various disciplines, some of which provide information and knowledge in very basic areas. There is something called a basic concept. And a concept is not the same as a principle. And it's not the same as a law. And it's not the same as a term, or a fact. A concept is something else, and there are relationships among concepts, and there are symbols that represent them. If you don't understand those things, you're not going to understand any science, and you are certainly not going to be able to use it solve any kind of problem. If you don't understand even the most basic concepts of physics or the relationship among the concepts of physics, you're not going to be able to apply those to solve personal or societal problems. And the people who have to deal with such societal problems are

oftentimes teams of Phd's. The SS&C project attempts to provide science, natural science, for every child, for six years, ultimately K-12, if we get an elementary program going. It advocates that that study be sequenced and well coordinated. In the middle years, we are suggesting that this be integrated and at the high school years be coordinated. We believe that at the high school level, particularly grades 10, 11, and 12, the level of understanding needed by a teacher to teach anything with any depth at all will not permit integration, as desirable as that might be. And I'm talking about integration among sciences, not going to other fields. I'm saying you might be able to have two-field integration, but I doubt seriously that you could have three-field integration. I'll give you an example of a relationship in biology which happens to have relationships among several other fields. I bring it up because I'm surprised that most people aren't familiar with it. It's the Weber-Fechtner Law in biology. A rather simply law that is responsible for the fact that in astronomy we have certain ways of assigning magnitudes for stars. That's astronomy - a biological law. In chemistry, it's why we use pH; in physics, it's why we use decibels. It's the simple law that spans the disciplines, and few people in science teaching have the slightest understanding of that law or where the decibel comes from, or where the pH comes from, or where the magnitude of stars comes from. A simple biological law that can be learned in grade 7, where we think we can teach it. It's a protective device that protects the species. If you have a stimulus acting and you want to detect a change in that stimulus, you have to present a stimulus that is proportional to the stimulus already acting. That means that it has to be logarithmic. That's true of taste, acidity that is. It's true of hearing, sight, and it's true of pressure. And it's true for any sensory thing for any organism. A fundamental law of science, and that's what I'm talking about when I say integrated or crossing disciplines. Other laws are not like that - there are other laws that are isolated to a particular discipline and may not have much applicability. There are other laws which have no applicability, thank God. They're interesting in their own right, and their worth learning because it's fun to do this. And someday, someone may even find an application. I studied non-Euclidean geometry once and I asked the teacher near the end of the course, "what possible use is there for this stuff" and she said "none, I hope". I have a lot of respect for that lady, and never did I see an

application for it.

We're trying in SS&C to present a sequenced, coordinated, instruction as I've described it with integration at the middle level. We believe that you should have direct experience with a phenomenon before you symbolize it or begin to use it in equations or relationships. Take into account where people are - that means preconceptions - the jargon is preconceptions, the old language used to say start where the kid is. So our new jargon says preconceptions. They mean the same thing. Focus on fewer topics, less is more, we agree with that. Much of what I'm saying, by the way, comes out of Chapter 13, of Science for All Americans. Jim Rutherford has looked at all of this and has a much more ambitious and difficult task to do the things he wants to do. I'm absolutely convinced that essentially everyone can understand the sciences at a high level, high compared to what we are doing now, which is generally trivial. People now don't understand. You know that. The tests are horrible. You know that. We're not measuring the kinds of understandings that we desire, partly because it's difficult to make such assessment instruments, and people are working on that. But partly too, we are forced to teach huge quantities of material in order to satisfy accountability. So you are required to cover large amounts of material nobody is learning. Very often the material is so abstract, and the level varies so much over the time that you have, that it's just a wasted effort.

Where are we now and what are we trying to do? The project at this moment has created a core of science that we believe essentially all kids should understand when they have graduated from high school. We've tried to look carefully at Science for All Americans. We've looked at the goals. We've looked at the themes. In many cases we've able to categorize or group material according to those themes. We've also tried very hard to recognize that even though there is no such thing as the scientific method, there are such things as processes of science that are fairly legitimate. You can see these processes occurring in science. I'm talking about things like classification, that's a process used by scientists, and I'm talking about making observations, and drawing inferences, and forming hypotheses. People try to account for something, creating metaphors for what's happening, and seeing if that metaphor works, and modifying it when they

run into some situation that forces them to modify it. As you know, kids learn our scientific metaphor, like F=ma. That's a scientific metaphor. The minute you finish testing them for it, they go back and use the old ones. They believe they are taking the test to do what we want them to do. They really don't believe what they are taught because they've never been forced to confront their own experience. Their experience tells them that our laws are wrong. You've never given them any experience which violates that. You create all these abstract situations which they don't understand anyway, and don't even believe exist. They've got to have the experience and that's what we're trying to do. The SS&C content core is presently out for review to about 200 people who participate in some way with this project. Many of you will shortly receive copies because you're involved in it. We're asking people to provide the necessary feedback, and the material will be revised and then it will be used by all the centers we have in the project. It will also be distributed to publishers and others who may want to begin to produce the materials for use in schools. I have a copy here. Let me talk about the SS&C project is being developed. It involves a number of centers working somewhat independently but also working through a coordination center (NSTA). There is a separate, independent documentation and evaluation component being carried out by Iris Weiss, at Horizon Research. Iris has a subcontract to document precisely what's happened, since the project's inception. It is the first time, I believe, any kind of a major project has had that kind of documentation. She's a tough documenter. She gets at the facts. She doesn't hesitate to identify things the way she sees them, and that gives us, credibility. We like that. These various centers, of which Houston is one, each produce materials by a particular mode that they have chosen to follow with agreement on the core. When you've identified the core of science, that doesn't mean you have specified how it's to be taught. We are ready to accept the idea that you can teach something in a variety of ways and accomplish the same goal. We have set down what we believe are the goals, and these centers design ways of achieving them. For example, in Iowa, Bob Yager is trying to achieve the same set of goals, with the same core, by means of a technique that he calls STS, an attempt to look at problems and issues. When he's finished doing this, the matrix of what kids have learned should match the matrix that we have

described here in the core. In Puerto Rico, where Manuel Gomez is running the project with something like thousands of kids, he's attempting to do a very structured, systematic, highly top-down arrangement where his small group of very competent people are presenting what looks like interesting and exciting material. He's working with these schools and will ultimately implement it in all of them. Houston is where we really have the most movement so far because we started there, Linda Crow and Bill Thompson of Baylor College of Medicine, working with the Houston Independent School District and Conroe, are both here. Their's is an attempt to work with teachers, it's not a top-down or bottom up, but sort of like a middle out. You'll hear more about that, where the teachers are directly involved in some cases preparing the materials and in other cases trying to provide the necessary formative evaluation of materials that are developed by teams of teachers, scientists, and others. The other sites include North Carolina, where the entire state's involved, and California where Tom tells me there are 214 schools involved - that's a complex situation out there and difficult to assess. They don't have that much money and it's hard to see what they're doing and I'm anxious to see what they can accomplish. So there are quite wide variations in the utilization of this mode and there are places attempting to do Scope and Sequence that are not being funded. Kokomo, Indiana claims that they have taken the ideas we have and simply took the whole district and made the change themselves without support. We've been working with a number of very elite independent schools which are anxious to make the change. I myself have visited and consulted with the Newman School in New Orleans and two or three schools in Washington D.C. that are expressing interest. North Carolina is one of those states that did receive a systemic initiatives grant from NSF, and that's coupled tightly to the Scope and Sequence Project. So we expect that to be significant assistance to that statewide effort. I want to be sure to give Linda adequate time to talk about the specific situation in Houston, but I'd like to make a few more comments about the general project and it's implications for teacher education. Did you see last Wednesday's USA Today, that little pull-out section? It's a little pull-out section on education - math and science education. They have a couple paragraphs on what we're doing, they have a couple paragraphs on Jim's project. And when they did the interview, I said one of the nice things

about Scope and Sequence is that it will help solve an important problem. The problem has to do with elementary school teachers. The fact that in this country most elementary school teachers have never studied science at all, anything, even in high school - no quantitative science. As a consequence, it is very difficult for them to do anything serious with science at the elementary school level, and I pointed out that if we have SS&C in place, and every child that came out of high school had six years in physics, chemistry, biology, earth and space science, those people who would become elementary school teachers would not need to have college science courses. It would not be necessary. By the way, that is the way it is done in at least one other country in the world. Elementary school teachers, in fact, are trained that way, only in high school science. With this program in place, none of the elementary science teachers will require any science in college. Now about teacher education. Let me point out first and foremost that you hear a lot of stuff about how bad teachers are. You hear this business about how we folks come from the low end of the ability distribution, our average SAT's are low compared to these other groups, and all that stuff. People who make that statement don't understand simple statistics. If you take a large distribution of people, and teachers can constitute a huge distribution of people, roughly 2.3 or 2.4 million, and you look where the mean is on any measure at all, it's going to be below the mean of a smaller sample. A smaller sample like, for example, the people who will become research scientists at which there are 60,000 or 70,000 physical scientists. Now the reality is, that if you took the top end of the distribution of teachers, people who become teachers, the absolute number of people at the top end of the SAT is larger for teachers than for the research scientists. The absolute number of people who are very, very bright is much greater than the absolute number of people who are going to become research scientists. That may not be good, but it's true. You're dealing with a huge distribution of people, and there are many very bright young people who are going into teaching, and that's important to remember. And there was a time when that number was even larger, when opportunity for young women was restricted largely to teaching. The number of very bright people in teaching was much higher than it is now. They've left - because other opportunities presented themselves, and they lowered our average by doing so. But that's

something else. And what does this project on Scope and Sequence imply for teacher education? If you're teaching at the middle level, you need to understand science in several areas. You need to understand the basic laws, basic principles, basic concepts of at least these four areas. That means that you don't go and get a baccalaureate degree in physics. You have to study several areas in significant depth. You need a thorough grounding in physics, chemistry, biology, earth and space science. If you don't have it, and many don't, there should be some kind of inservice opportunity and that's the immediate problem. The immediate problem is inservice, the ultimate problem is preservice. You can do something about the inservice because we found in Houston that those teachers are remarkably capable of learning that material well and understanding what they are doing with relatively short amounts of time, and they enjoy it. They are competent to learn it, and they are anxious to do so and they do very well. Jim Rutherford has suggested that if teachers learn the subject matter in the context of the materials they are teaching in class, they'll be interested in learning it and they'll succeed in learning it. And that's the context in which we're recommending people to have preservice, not as separate courses in science. That's one implication. Second is preservice: obviously you have to have some kind of broad curriculum. I'm talking about secondary school now. At the middle level and at the high school level it would be desirable to have two field preparation, at least. There are only 19,000 physics teachers in the United States who teach one or more courses in physics in high school. Fewer than 2000 of those teach nothing but physics, and there are huge numbers of those who teach physics, chemistry, biology,... for which they have no prepar[illegible] at all, and they don't understand any of the material, and they can't deal with it adequately. And [illegible]h that, the only other comment I would like to make is that we really are aiming to focus much more strongly on experience, on hands on, on laboratory, on activities where people work with real phenomenon. And I don't mean simulation and those little ditto sheets that are supposed to be teaching the laboratory. Only they are really some kind of analogy. They have nothing to do with reality. I'm talking about real phenomena. There's a real effort in this project to move things in that direction. Some of the materials that have been developed- will be available for use in schools for the 1992-93 school year. The blocks that are

coming out of Houston are going through review and revision this summer. They will be refined next year, and made available in general for the following year. We have reason to believe that there will be materials for publishers available in time for the California adoption, a year ahead of Texas adoption, that will properly provide these kinds of experiences. We are hoping that our project will focus more on the kind of thing illustrated by this little transparency. With that, I'll be happy to respond to any kind of questions. I didn't say anything about assessment - we are running a rather large assessment project. If you want details, I would be happy to provide them, but that seems to me to be peripheral. Now for questions.

Resources

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SYNTHESIS OF GROUP DISCUSSIONS: SCIENCE REFORM AND TEACHER EDUCATION IN THE STATE OF TEXAS

Carol L. Stuessy
Texas A&M University

Introduction

The title of our conference: "Science Reform: Implications for Teacher Preparation," emphasizes the importance of teachers in the process of implementing reform. Educational reform is never easy, but it becomes particularly difficult when any group declares itself the one "in control" and underestimates the powerful role of the teacher in the process The teacher basically is the most important agent of change within any educational reform effort. Essentially, it is the teacher who effectively does or does not do the job. The teacher is the one who formally educates the children of this generation and passes on the dreams of the society to the next. The teacher inspires, interfaces, translates, motivates, encourages, facilitates, evaluates. It is a powerful thought, is it not, that it is the teacher who actually transforms the lofty goals of any "ideal curriculum" into the reality of "classroom science" for the next generation? Behind the closed door of the isolated classroom, the teacher is expected to be the one who indeed "makes it happen" for the future needs of our society and the individuals who comprise it. As our educational system now operates, all other stakeholders in the educational process play minor roles in comparison to our teachers.

Many of the stakeholders were represented at the conference - state officials, district administrators, textbook publishers, science professors, teacher educators, community leaders, parents, as well as the ones who ultimately effect the reform, the classroom teachers. In the discussion groups, representative stakeholders were charged with discussing how best to set the stage for reform for two different groups of teachers: preservice teachers and practicing classroom teachers. Most of the comments centered on inservice preparation of existing classroom teachers

for the reform, although some were directed towards preservice university preparation and others applied to both groups. Many of the discussants described their first-hand experiences as practicing teachers in having been required to implement the latest "new plan" in their classrooms to solve a new set of ills. Many were very familiar with the concept of having to do "just one more thing" every year with little compensation, time, or assistance in implementing new curriculum, instructional practices, discipline plans, or educational policy. Other comments were more focused on the university side of the problem, which overlaps with preparation of classroom teachers who can model and discuss the new reform as it applies to direct classroom practice.

The process of synthesizing the reports from the discussion groups first involved a notation of the similarities among the groups regarding suggestions and comments about "teachers and/or classrooms." These similarities, noted as "topical headings," such as "need for information," "common vision," and "flexibility," became place holders for clusters of similar comments. Subsequent readings indicated that some headings were not well supported; those were incorporated into other headings or eliminated. From the clusters associated with each topical heading, a few major ideas were generalized that appeared to be supported by each of the discussion groups. Each of those ideas is summarized below.

Needs of Teachers In the Reform Process

Teachers Need Information

Teachers at both the level of preservice and inservice education need clear, concrete, information about the science reform efforts being planned for the State of Texas. Many of the teachers at our conference were not at all clear about the new options regarding what and how to teach children in science. On the first line of business, teachers need answers to the most common questions about what, for whom, and when. Teachers also need information about the models for curriculum, instruction, and evaluation and guidelines regarding how the models can be implemented effectively. They actually would like to see "clear modeling of actual teachers

implementing this type of curriculum."

If outcomes of science reform are expressed in terms of "scientific literacy" and that term is not well defined or understood by the major stakeholders in the enterprise of science reform, how can one expect a common purpose to be shared by parents, administrators, classroom teachers, children businessmen, and university professors? If teaching practices and testing procedures are very different from those understood to be appropriate for traditional science are required in order to meet the new outcomes of science reform, then teachers need information about how to get there. If the district or State goals include not only scientific literacy goals for K-12, but preparation for college science classes and/or job preparation skills as well, teachers need to understand how these goals fit together and "make sense" in the science curriculum.

One cannot ignore the implications that reform has for standardized testing practices. Most practicing teachers were prepared to teach science that resulted in traditional learning outcomes easily measured by mass-testing methods. Outcomes associated with the new science curricula include conceptual understanding, problem solving, reasoning, making and testing conjectures, and other higher-level thinking skills. Although teachers understand the worthiness of these new goals, instructional practices for reaching these goals are often foreign to teachers who were prepared to teach for content-oriented goals. Teachers ask questions about how to teach for higher-level thinking outcomes and how to measure whether students have indeed acquired them. The problem is exacerbated when one realized that, at this time in out State, methods for evaluating learning and teaching at district and state levels in many cases contradict the reformed vision of K-12 science education.

Teachers need accessible, teacher-friendly, effective communication channels at all levels for information that directly affect classroom practice. They also need information from other teachers who are implementing changes in curriculum. In some instances, they may need university classes or staff development plans to help them increase their knowledge in particular subject areas or to help them increase their repertoire of instructional and classroom management strategies in order to facilitate the development of the newer, less familiar leaning outcomes

associated with higher-level thinking, shared decision making, and collaborative learning.

Teachers Need to Share A Common Vision

Direct knowledge that the vision is shared by all stakeholders in the reform enterprise would go a long way to encourage traditional teachers to take the risks associated with altering instruction and testing practices that are necessary in reforming science education in this State. All stakeholders, including teachers, need to understand the outcomes that are expected from science reform efforts such as SS&C and Project 2061. All too often parents, district personnel, State agencies, and even university professors, are identified as barriers to change. A special note was made in several discussions about the role of high school science classes in preparing students for university science classes. One characteristic of science education reform is that the curriculum is meaningful, relevant, and contextual to the present life of the developing learner. There is no justification for content-bound mastery of factual information because it prepares students for the "next level" of education, whether it be college, high school, junior high or middle school, or fourth grade. This is a difficult concept for many, particularly those stakeholders in the educational enterprise who view the primary job of the teacher as preparing learners for college.

New teachers adopt instructional practices that have been modeled to them by their previous teachers: cooperating teachers in student teaching, university science professors, and high school science teachers. In a time of reform, inexperienced preservice students will need numerous examples of experienced teachers who model the shared vision of the "new" science curriculum. In field work and student teaching, preservice students might be paired to work with teachers who share the vision of reform. University science classes and methods classes could open the communication between them and include the classroom teachers who share the dream and ultimately hold the major responsibility of translating the dream into practice.

Common perceptions associated with the system of the university include "science departments at the university [that are] fragmented" ... "turf issues within the various science departments," ... "little incentive for science professors to become involved in the changes needed to enhance science education," and "current focus of administrators on granted funding [that]

influences faculty's budgeting of their time", as well as "methods teachers who are out of touch with the reality of the schools." A collaborative, shared effort must include university professors who understand and buy into the vision of science education reform. The public school science classroom may need redefining as a "university laboratory" for university professors and students to acquire first-hand information and experience about the new methods associated with teaching and learning science.

Teachers Need Resources and Time Flexibility

The implications of reform for those involved in preservice teacher preparation are easier to discuss than the complex issues associated with staff development for practicing teachers. Needs in terms of resources and time are often mentioned together. Even when resources are available, teachers must find the time to juggle overloaded classes, paper grading, science laboratory preparation schedules, and teacher conferences in order to take advantage of resources available to them. In order to adopt the vision, practicing classroom teachers need a system of support and communication that provides information, resources and flexibility. The comments that follow touch on several ideas that were expressed by the groups.

In some ways, Texas is late in adopting the idea of science reform. Teachers need resources available at the national level to assist them in acquiring materials, new knowledge, feedback, and support. Resources proved by various sources including educational institutions and professional groups such as the National Science Teachers Association should be available through communication networks that are accessible to teachers, during the teachers' school days. Other resources closer to home include "experts" in particular areas that include parents, community, district, peer professional groups, and university. Local networks also could make those resources accessible to teachers. One suggestion was that preservice teachers and university personnel should be included as team members to work as "experts" within the team who perform specific, important functions associated with their own field of interest and expertise.

Teachers need flexibility in their work days to allow them to access information , use communication networks, find resources. Flexible time management would allow teachers time to

seek and acquire resources, to structure instructional time wisely, to attend formal staff development programs, to plan curriculum with other teachers and preservice teacher, and to meet with parents and community leaders. Time management models that maximize flexible scheduling and vary instructional grouping would allow time for teachers and science supervisors, for example, to consider issues and solve problems associated with implementing science reform. Integration of university students and supervisors into the instructional day could be a viable method to acquire some flexibility, as well as to give more actual experience to preservice education students.

Teachers Need Support

Teachers need support in instituting a science reform that breaks down the traditional 19th century barriers of discipline-bound science. Change always brings with it uncertainty, fear of failure, and some reluctance to take risks. Educational support can assist the change process, however. Much of the uncertainty and reluctance may be caused by a lack of adequate background knowledge in other science subject areas. Teachers have been prepared to teach the discipline-bound sciences of biology, chemistry, physics, and earth science. Science, regardless of discipline, is a way of knowing about the world that is not often depicted in the discipline-bound science classroom. Chemistry as a subject, for example, is not often experienced by students as a way of making sense of the natural and technological world in which they live. Discipline-bound science is not often taught as a unique method of inquiry that allows students to perceive its usefulness and unique contributions in their everyday lives. This viewpoint is particularly difficult for a secondary school teacher whose preparation for teaching required an in-depth study of one of the major disciplines. This training is very different than a course about science that encompasses all disciplines and focuses on the nature of science as a process and the disciplines as particular modes of inquiry. The generalized term "science teacher" and its new ideas and processes related to the teaching of science as "less is more." In comparison, the term "physics teacher," which actually connotes depth in a particular subject area, may represent a more restrictive vision of teaching that does not easily mesh with new interdisciplinary and/or integrated science viewpoints.

Teachers also need support in changing their attitudes about science reform. Negative attitudes about science reform may indicate a teacher's lack of understanding and knowledge about plans for reform, self-confidence regarding ability to change, distrust in administrators and state-level decision makers, disappointment in not being included in the decision making process at some level, or a lack of recognition for the commendable job they have been doing already. Rewards and feedback that indicate teachers' effectiveness in implementing change may play an important role in changing teachers' attitude about the change. Another motivator may be explicitly stated permission and support to experiment, innovate, and challenge their students in ways that are supported by their peers, their direct supervisors, and higher administration.

Questions Raised

No longer can teachers be expected to do their jobs in isolation of the other stakeholders within the educational enterprise. The task of preparing our children to meet the world of the future reaches far beyond the notion of the isolated classroom with its closed door. Effective two-way channels must be established and nurtured between and among teachers, school administrators, families, community members, university personnel, and numerous psychological support persons. Do we know who the major stakeholders are in the enterprise of science education reform? Can we assist in establishing networks and vehicles to stakeholders? Can we involve teachers at each level to assure that they receive the information, shared vision, resources, flexibility, and support that they need in order to be effective agents of change?

MAY 17-18 SCIENCE REFORM CONFERENCE ATTENDEES

Teachers (12)

Louise Ables	College Station ISD
Mary Bertl	Arlington ISD
Jan Harmon	Mansfield ISD
Vy Hammond	Seguin ISD
Paulette Richardson	Belton ISD
Colleen Holmes	Bryan ISD
Sue Elliott	Bryan ISD
Dr. Elaine Smith	College Station ISD
Melissa Rogers	Mansfield ISD
Abel Candia	Harlandale ISD
Kathryn Powell	Harlingen ISD
Carol Batiste	Beaumont ISD

School District Representatives (8)

Bill Rogers	Goose Creek ISD
Linda Densman	Hurst-Euless-Bedford ISD
Nan Jackson	Victoria ISD
Diane Heintz	Victoria ISD
Ron Converse	Conroe ISD
Katherin Mays	Sweeny ISD
Jim Zuhn	College Station ISD
George Faulkner	San Angelo ISD

State/County Representatives (4)

Jim Collins	TEA
Becky McCoy	TEA
Cheryl Emanuel	Louisiana State Dept. of Education
Bobbie Sparks	Harris Co. Dept. of Education

Center for Mathematics and Science Education - Texas A&M (6)

Dr. "Doc" Dockweiler	Director, & Professor, Mathematics Education
Dr. Bob James	Member, & Professor, Science Education
Dr. Delmar Janke	Member, & Associate Professor, Science Education
Dr. Gerald Kulm	Member, & Professor, Mathematics Education
Dr. Jane Schielack	Member, & Assistant Professor, Mathematics Education
Dr. Carol Stuessy	Member, & Assistant Professor, Science Education

Texas A&M University (11)

Dr. Jane Stallings	Dean, College of Education
Dr. Dean Gage	Provost & Vice Pres. for Academic Affairs
Dr. Dean Corrigan	President's Deputy for Educational Leadership
Dr. John Fackler	Dean, College of Science
Dr. Peter McIntyre	Professor of Physics
Dr. "Pat" Patterson	Professor of Biology
Dr. Karyn Bird	Professor of Veterinary Pathobiology
Dr. Bob Presley	Professor of Oceanography
Dr. John Morris	Professor of Curriculum and Instruction
Dr. Donna Wiseman	Professor of Curriculum and Instruction
Dr. Larry Peck	Professor of Chemistry

University Representatives (14)

Dr. Melanie Lewis	Southwest Texas State University
Dr. Dick Hammon	Southwest Texas State University
Dr. Sandra West	Southwest Texas State University
Dr. Bob Jones	University of Houston - Clear Lake
Dr. Eugene Chiappetta	University of Houston
Dr. John Ramsey	University of Houston
Barbara Mailot	Angelo State University
Dr. Marian Marinello	University of Texas - San Antonio
Dr. John Moore	Stephen F. Austin State University
Dr. Charles Orsak	Navarro College
Dr. Bill Thomson	Baylor College of Medicine
Dr. David Labrie	West Texas State University
Dr. Robert Holland	University of Mary Hardin-Baylor
Dr. Betty Crocker	University of North Texas

Education Service Centers (3)

Jo Ann Brown	Region 4
Christine Tremonte	Region 4
Sandra Johnson	Region 13

Publishers (9)

Libby Allison	MacMillan/McGraw-Hill
Laura Jo Fojtasek	MacMillan/McGraw-Hill
William Royalty	Prentice-Hall
Kathy French	Prentice-Hall
Ted May	Optical Data Corporation
Jennifer Swift	Holt, Rinehart, and Winston
Kathy McKee	Holt, Rinehart, and Winston
Richard Monnard	Holt, Rinehart, and Winston
Gene Smith	Glencoe

Graduate Students (12)

David I .th	Texas A&M
Bill Jasper	Texas A&M
Kathleen Mittag	Texas A&M
Gil Naizer	Texas A&M
Carol Simmons	Texas A&M
John Fossa	Texas A&M
Barbara Bolin	Texas A&M
Barbara Sultis	Texas A&M
Elizabeth Bryant	Texas A&M
Marc Horn	Lewis Research Center
Robin Rustad	Stephen F. Austin State University
Alicia Hayes	Scotlandville Magnet School

Others (8)

Dr. James Rutherford	AAAS, Project 2061
Peggy Carnahan	Project 2061, San Antonio
Deborah Larson	Project 2061, Wisconsin
Dr. Bill Aldridge	NSTA, SSC Project
Dr. Linda Crow	Houston Project, SSC
Dr. Bob Fitzmaurice	NASA
Teri Metcalf	Texas Alliance
Mike Downey	Texas A&M Office of Public Information

TOTAL ATTENDEES = 87

ADDRESS LIST FOR CONFERNENCE PARTICIPANTS

Louis Ables	College Station ISD	2720 Celinda Circle	College Station	TX	77840
Bill Aldridge	SS&C	1742 Connecticut Ave.,NW	Washington	DC	20009117
Libby Allison	MacMillan/McGraw-Hill	5631 Balkan	Columbus	OH	43231
Carol Batiste	Beaumont ISD	1810 Euclid	Beaumont	TX	77705
Mary Bertl	Fort Bend ISD	1203 W. PioneerPkwy	Arlington	TX	76013
Karyn Bird	Dept. of Vet. Pathology	Texas A&M University	College Station	TX	77845
Barbara Bolin	Department of IVTE	Texas A&M University	College Station	TX	77845
Jo Ann Brown	Region IV ESC	1705 Lamar	Richmond	TX	77469
Elizabeth Bryant	Room 204, Zachry Bldg.	Texas A&M University	College Station	TX	77843
Abel Candia	Harlandale ISD	4823 Casa Oro	San Antonio	TX	78233
Peggy Carnahan	Project 2061, Site Coord.	11933 IH 10 West	San Antonio	TX	78230
Eugene Chiappetta	University of Houston	4800 Calhoun	Houston	TX	77004537
Jim Collins	Texas Education Agency	1701 N. Congress Ave.	Austin	TX	77841
Ron Convrse	Conroe ISD	501 N. Thompson	Conroe	TX	77301
Dean Corrigan	President's Deputy	Texas A&M University MS 4226	College Station	TX	77845
Betty Crocker	Univ. of North Texas	P.O. Box 8454 NTStation	Denton	TX	76203
Linda Crow	Baylor Col. of Med. Twrs	1709 Dryden, Suite 709	Houston	TX	77030
Linda Densman	Hurst-Euless-BedfordISD	1849 Central Dr.	Bedford	TX	76022
C.J. Dockweiler	Department of EDCI	Texas A&M University MS 4232	College Station	TX	77845
Mike Downey	Office of Public Info.	Texas A&M University MS 4245	College Station	TX	77845
Sue Elliot	Texas Education Agency	1701 N. Congress Ave.	Austin	TX	77845

Cheryl Emanuel	State Dept. of Education	3387 Brady St.	Baton Rouge	LA	78701149
John Fackler	College of Science	Texas A&M University MS 3257	College Station	TX	77840
George Faulkner	San Angelo ISD	1621 University Ave.	San Angelo	TX	76904
Bob Fitzmaurice	NASA Johnson Space Cntr	Mail CodeAP4	Houston	TX	77058
Laura Jo Fojtasek	MacMillan/McGraw-Hill	3100 Oak Ridge	Temple	TX	76502
John Fossa	Department of EDCI	Texas A&M University MS 4232	College Station	TX	77840
Kathleen French	Prentice Hall	2528 Creekwood Lane	Fort Worth	TX	76123
Dean Gage	Provost and Vice Pres.	Texas A&M University MS 1248	College Station	TX	77840
Dick Hammond	Department of C&I	Southwest Texas State University	San Marcos	TX	78666
Vy Hammond	Seguin ISD	McQueeny Elementary School	McQueeny	TX	78123
Jan Harmon	Mansfield ISD	3221 HarmonRd.	Mansfield	TX	76063
Alicia Hayes	Scotlandville Magnet Schl	8675 Elm Grove	Baton Rounge	TX	70807
Diane Heintz	Victoria ISD	217 Wearden	Victoria	TX	77901
Robert Holland	U of Mary-Hardin Baylor	Box 8017	Belton	TX	76513
Collen Holmes	Bryan ISD	1400 Pecan	Bryan	TX	77803
Marc Horn	Lewis Research Center	2731 San Felipe	College Station	TX	77840
Nan Jackson	Victoria ISD	3002 North St.	Victoria	TX	77901
Bob James	Department of EDCI	Texas A&M University MS 4232	College Station	TX	77840
Delmar Janke	Department of EDCI	Texas A&M University MS 4232	College Station	TX	77840
Bill Jasper	College Station ISD	1601 N. Bluebonnet Circle	College Station	TX	77840
Sandra Johnson	Region XIII ESC	604 East Covington	Austin	TX	78753
Dr. Bob Jones	Un of Houston-Clear Lake	2700 Bay Area Blvd.	Houston	TX	77058
Gerald Kulm	Department of EDCI	Texas A&M University MS 4232	College Station	TX	77840
David Labrie	Department of Biology	West Texas State University	Canyon	TX	79016

Deb Larson	McFarland High School	5101 Farwell	McFarland	WI	53558
David Leeth	Department of EDCI	Texas A&M University MS 4232	College Station	TX	77840
Melanie Lewis	Department of Biology	Southwest Texas State University	San Marcos	TX	78666
Barbara Mailot	Angelo State University	216 Edinburgh	San Angelo	TX	76901
Marian Martinello	Un of Texas- San Antonio	310 S. St. Mary's St., Suite #1516	San Antonio	TX	78205
Teodore T. May	Optical Data Corporation	30 Technology Dr., Box 4919	Warren	NJ	07059
Katherin Mays	Sweeny ISD	P.O. Box 865	Sweeny	TX	77840
Becky McCoy	Texas Education Agency	1701 N. Congress Ave.	Austin	TX	78701149
Peter McIntyre	Department of Physics	Texas A&M University MS 4232	College Station	TX	77845
Kathy McKee	Holt, Rinehart, &Winston	1627 Woodland	Austin	TX	78741
Teri Metcalf	Department of EDCI	Texas A&M University MS 4232	College Station	TX	77845
Kathleen Mittag	Department of EDCI	Texas A&M University MS 4232	College Station	TX	77840
Richard Monnard	Holt, Rinehart, &Winston	1627Woodland	Austin	TX	78741
John Moore	Stephen F Austin State Un	1936 North Street	Nacodoches	TX	75962
John Morris	Department of EDCI	Texas A&M University MS 4232	College Station	TX	77840
Gil Naizer	Department of EDCI	Texas A&M University MS 4232	College Station	TX	77840
Charles Orsak	Navarro College	212 N 30	Corsicana	TX	75110
Pat Patterson	Department of Biology	Texas A&M University MS 3258	College Station	TX	77843
Larry Peck	Department of Chemistry	Texas A&M University MS 3255	College Station	TX	77840
Kathryn Powell	Harlingen ISD	1514 E. Crockett	Harlingen	TX	78550
Bob Presley	Dept. of Oceanography	Texas A&M University MS 3146	College Station	TX	77845
John Ramsey	University of Houston	4800 Calhoun	Houston	TX	77004537
Paulette Richardson	Belton ISD	Rt. 1, Box 564	Moody	TX	76557
Melissa Rogers	Mansfield ISD	2004 Cypress Point #2017	Arlington	TX	76010

William Royalty	Prentice Hall	10308 Lyndon Rd.	Oklahoma City	OK	73120
Robin Rustad	Stephen F Austin State Un	1936 North Street	Nacogdoches	TX	75962
James Rutherford	AAAS	1333 H. Street, N.W.	Washington	DC	20005
Jane Schielack	Dept of Mathematics	Texas A&M University MS 3368	College Station	TX	77840
Carol Simmons	Department of EDCI	Texas A&M University MS 4232	College Station	TX	77840
Elaine Smith	College Station ISD	1213 Merry Oaks	College Station	TX	77840
Gene Smith	Glencoe Publishing	5811 Thoreau Ln.	Arlington	TX	76016
Bobbie Sparks	Harris Co. Dept. of Ed.	6300 Irvington Blvd.	Houston	TX	770225618
Jane Stallings	Dean, Col. of Education	Texas A&M University MS 4232	College Station	TX	77840
Carol Stuessy	Department of EDCI	Texas A&M University MS 4232	College Station	TX	77840
Barbara Soltis	Department of EDCI	Texas A&M University MS 4232	College Station	TX	77840
Jennifer Swift	Holt, Rinehart, &Winston	1627 Woodland	Austin	TX	77841
Bill Thompson	Baylor Col. of Medicine	Room 6335	Houston	TX	77030
Christine Tremonte	Region IV ESC	5510 Fountainbridge	Houston	TX	77069
Sandra West	Department of Biology	Southwest Texas State University	San Marcos	TX	78666
Donna Wiseman	Department of EDCI	Texas A&M University MS 4232	College Station	TX	77840
Jim Zuhn	College Station ISD	1812 Welsh	College Station	TX	77840